

CLAIMS:

1. X-ray imaging device with computer means (17) which is provided for visualizing the blood flow in a coronary vascular tree of a patient such that the visualization is effected based on data which contain a first set (1) of X-ray projection images of the vascular tree in various phases of the heart cycle, a first ECG (2) of the patient recorded simultaneously with the first set (1), a second set (6) of X-ray projection images recorded during or after the administration of a contrast agent and a second ECG (7) of the patient (15) recorded simultaneously with the second set (6), which computer means (17) comprise a program control which operates in accordance with the following method steps for determining the time-dependent concentration of contrast agent within the three-dimensional structure of the vascular tree:
 - Reconstruction of the three-dimensional structure of the vascular tree during the various phases of the heart cycle using the first set (1) of X-ray projection images and splitting of the structure into a number of vascular segments (5, 8);
 - Determining the time-dependent concentration of contrast agent (9) within the reconstructed three-dimensional structure of the vascular tree by
 - aa) Assignment of the X-ray projection images of the second set (6) to a respective phase of the heart cycle using the recorded second ECG (7);
 - bb) Finding local image areas assigned to the individual vascular segments (8) within the X-ray projection images of the second set (6) corresponding to the spatial positions of the vascular segments (8) in the respective phase of the heart cycle according to the three-dimensional structure of the vascular tree;
 - cc) Determining the concentration of contrast agent within the vascular segments (8) by evaluating the X-ray absorption within the local image areas found in the method step bb);
 - Visualization of the flow of contrast agent through the three-dimensional structure of the vascular tree according to the time-dependent distribution of contrast agent (9).

2. X-ray imaging method as claimed in claim 1, characterized in that the second set (6) of X-ray projection images is recorded during or after the administration of the contrast agent, while the vascular tree fills with contrast agent and then the first set (1) of X-ray projection images is recorded after the vascular tree is completely filled with contrast agent.
3. X-ray imaging device as claimed in claim 1, with means (10, 11, 12, 13) for generating the first and the second set of X-ray projection images of the coronary vascular tree of the patient (15) under various projection directions and with means (18) for recording the ECG of the patient (15) during the recording of the first and second sets of X-ray projection images.
4. X-ray imaging device as claimed in claim 2, wherein the computer means (17) are arranged such that during or after the administration of the contrast agent first the second set (6) of X-ray projection images is recorded while the vascular tree fills with contrast agent, and then the first set (1) of X-ray projection images is recorded, after which the vascular tree completely fills with contrast agent.
5. X-ray imaging device as claimed in claim 2 or 3, wherein the computer means (17) are further arranged such that the recording of the first and/or second set of X-ray projection images is effected at a plurality of projection angles by means of continuous rotation-X-ray imaging.
6. X-ray imaging device as claimed in one of the claims 1 to 5, wherein the computer means (17) are arranged such that for reconstructing the three-dimensional structure of a computer-aided modeling of the vascular tree is effected while eliminating the other anatomical structures contained in the first set (1) of X-ray projection images.
7. Computer program for an X-ray imaging device for visualization of the blood flow in a coronary vascular tree of a patient, wherein the computer program receives as input variables data which contain a first set (1) of X-ray projection images of the vascular tree in various phases of the heart cycle, a first ECG (2) of the patient (15) recorded simultaneously with the first set (1), a second set (6) of X-ray projection images recorded during or after the administration of a contrast agent and a second ECG (7) of the patient (15) recorded

simultaneously with the second set (6), which computer program on the computer means (17) of the X-ray imaging device implements a program control which operates in accordance with the following method steps for determining the time-dependent concentration of contrast agent within the three-dimensional structure of the vascular tree:

- 5 - Reconstruction of the three-dimensional structure of the vascular tree during the various phases of the heart cycle using the first set (1) of X-ray projection images and splitting of the structure into a number of vascular segments (5, 8);
- Determining the time-dependent concentration of contrast agent (9) within the reconstructed three-dimensional structure of the vascular tree by
10 aa) Assignment of the X-ray projection images of the second set (6) to a respective phase of the heart cycle using the recorded second ECG (7);
 bb) Finding local image areas assigned to the individual vascular segments (8) within the X-ray projection images of the second set (6) corresponding to the spatial positions of the vascular segments (8) in the respective phase of the heart cycle according to the three-dimensional structure of the vascular tree;
 cc) Determining the concentration of contrast agent within the vascular segments (8) by evaluating the X-ray absorption within the local image areas found in the method step bb);
15 - Visualization of the flow of contrast agent through the three-dimensional structure of the vascular tree according to the time-dependent distribution of contrast agent (9).
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8. X-ray imaging method for visualizing the blood flow in a coronary vascular tree of a patient having the following method steps:
25 a) Recording a first set (1) of X-ray projection images of the vascular tree during various phases of the heart cycle while simultaneously recording a first ECG (2) of the patient (22)
 b) Reconstruction of the three-dimensional structure of the vascular tree during
30 the various phases of the heart cycle from the first set (1) of X-ray projection images and splitting of the structure into a number of vascular segments (5, 8);

- c) Recording of a second set (6) of X-ray projection images of the vascular tree during or after the administration of a contrast agent while a second SECG (7) of the patient is being recorded;
- d) Determining the time-dependent concentration of contrast agent (9) within the 5 vascular tree's three-dimensional structure reconstructed in the method step b) by
- aa) Assignment of the X-ray projection images of the second set (6) to a respective phase of the heart cycle using the recorded second ECG (7);
- bb) Finding local image areas assigned to the individual vascular 10 segments (8) within the X-ray projection images of the second set (6) corresponding to the spatial positions of the vascular segments (8) in the respective phase of the heart cycle according to the three-dimensional structure of the vascular tree;
- cc) Determining the concentration of contrast agent within the vascular 15 segments (8) by evaluating the X-ray absorption within the local image areas found in the method step bb);
- e) Visualization of the flow of contrast agent through the three-dimensional structure of the vascular tree according to the time-dependent distribution of contrast agent (9) determined in method step d).
9. X-ray imaging method as claimed in claim 8, wherein first the second set (6) of X-ray projection images is recorded during or after the administration of the contrast agent, while the vascular tree fills with contrast agent and then the first set (1) of X-ray 20 projection images is recorded after the vascular tree is completely filled with contrast agent.
10. X-ray imaging method as claimed in claim 8 or 9, wherein the recording of the first and/or second set of X-ray projection images is effected using continuous rotation-X-ray imaging at a plurality of projection angles.
- 25 11. X-ray imaging method as claimed in any one of claims 8 to 10, wherein the recording of the second set (6) of X-ray projection images is effected at at least one fixed projection angle.

12. X-ray imaging method as claimed in any one of the claims 8 to 11, wherein a computer-aided modeling of the vascular tree, with elimination of other anatomical structures contained in the first set of X-ray projection images, is effected to reconstruct the three-dimensional structure in method step b).